

# Mars Sample Return Caching Strategy Steering Committee Report

Prepared by the MSR Caching Strategy Steering Committee (Chairs: G. Kminek<sup>1</sup> & M. A. Meyer<sup>2</sup>  
Members: D. W. Beaty<sup>3</sup>, T. Bosak<sup>4</sup>, A. Bouvier<sup>5</sup>, B. L. Carrier<sup>3</sup>, J. Delfa<sup>1</sup>, L. T. Elkins-Tanton<sup>6</sup>, K. A. Farley<sup>7</sup>, M. M. Grady<sup>8</sup>, J. A. Grant<sup>9</sup>, S. Gupta<sup>10</sup>, L. E. Hays<sup>2</sup>, A. Haldemann<sup>1</sup>, C. D. K. Herd<sup>11</sup>, L. Lemelle<sup>12</sup>, F. Moynier<sup>13</sup>, M. Schulte<sup>2</sup>, K. L. Siebach<sup>14</sup>, D. A. Spencer<sup>3</sup>, J. H. Trosper<sup>3</sup>, J. L. Vago<sup>1</sup>, M. Wadhwa<sup>3,6</sup>, K. Ziegler<sup>15</sup>)

<sup>1</sup>European Space Agency, <sup>2</sup>NASA Headquarters, <sup>3</sup>Jet Propulsion Laboratory, California Institute of Technology, <sup>4</sup>Massachusetts Institute of Technology, <sup>5</sup>University of Bayreuth, Germany, <sup>6</sup>Arizona State University, <sup>7</sup>California Institute of Technology, <sup>8</sup>Open University, UK, <sup>9</sup>Smithsonian Institute, <sup>10</sup>Imperial College London, <sup>11</sup>University of Alberta, Canada, <sup>12</sup>Centre national de la recherche scientifique, Lyon, <sup>13</sup>Institut de Physique du Globe de Paris, <sup>14</sup>Rice University, <sup>15</sup>University of New Mexico

working under the Terms of Reference provided by NASA and ESA

March 1st, 2021

## Recommended bibliographic citation:

MSR CSSC (2021) *Mars Sample Return Caching Strategy Steering Committee Report*. Prepared by the MSR Caching Strategy Steering Committee (Chairs: G. Kminek & M. A. Meyer Members: D. W. Beaty, T. Bosak, A. Bouvier, B. L. Carrier, J. Delfa, L. T. Elkins-Tanton, K. A. Farley, M. M. Grady, J. A. Grant, S. Gupta, L. E. Hays, A. Haldemann, C. D. K. Herd, L. Lemelle, F. Moynier, M. Schulte, K. L. Siebach, D. A. Spencer, J. H. Trosper, J. L. Vago, M. Wadhwa, K. Ziegler). Unpublished Report.

The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for planning and information purposes only.

## Introduction

The Caching Strategy Steering Committee (CSSC) was chartered by NASA and ESA to review a set of draft scenario-based decision guidelines for sample caching that are meant to inform operational decisions for future Mars Sample Return (MSR) systems and provide strategic guidance for Perseverance. In addition to internal discussions within the CSSC, a community workshop was planned to acquire input on the definition of what constitutes a scientifically return-worthy (SRW) sample collection and the decisional rationale for the formation of sample depots, and to integrate the workshop discussions and feedback to catalyze improved agreements on decision guidelines that can be implemented by NASA and ESA.

The CSSC was established in December 2020 with representatives from ESA, NASA, the MSR and Mars 2020 projects, Mars 2020 science team members, and the external Mars science community (see Appendices I & II - Terms of Reference and membership). The steering committee initially proposed a reformulation of the decision guidelines based on internal discussions, which was presented at the workshop. The CSSC also planned the community workshop, including how best to convey and receive information to maximize the workshop's output.

The MSR Sample Caching Strategy Workshop was held on Jan. 21, 2021. Those interested in the workshop were encouraged to submit emails of interest and were included on any workshop correspondence. Before the workshop, reading material, agenda, and draft guidelines were made available to all who expressed interest and 255 unique individuals participated/logged into the workshop. Presentations were made and discussions encouraged (see agenda Appendix III). Considering the challenges of remote discussion among over 200 participants, the chat dialog was saved and the opportunity to submit written feedback was left "open" for the following four days to gather additional comments from the community. All the workshop material is archived at:

<https://mepag.jpl.nasa.gov/announcements.cfm?expand=January%202021%20MSR%20Sample%20Caching%20Workshop>

Following the workshop, a subset of the CSSC was tasked with writing up the new draft guidelines, incorporating the community's input. The revised guidelines were passed through the CSSC for final acceptance. Below are the recommended updated decision guidelines and the definition for Scientifically Return Worthy (SRW). Also included in the Appendix IV are the original draft decision guidelines.

## Strategic Intent #1 & Decision Guideline

1. STRATEGIC INTENT: To ensure that at least one scientifically return-worthy (SRW) sample collection is available to the sample retrieval mission, a depot should be established when Perseverance has

assembled an SRW sample collection and before Perseverance undertakes significant additional mission risk.

#### Decision Guideline

- Prior to embarking on challenging traverses<sup>1</sup> through terrain that is inaccessible by the sample retrieval mission, or before reaching the Perseverance qualified lifetime of 1.5 Mars years, the Mars 2020 team should create a depot<sup>2</sup> of an SRW sample collection<sup>3</sup>. This depot must be in an area accessible to the sample retrieval mission.

<sup>1</sup>The traverse from Jezero crater floor up to the rim is through potentially difficult terrain, and the traverse path lengths between areas thought to be accessible for the sample retrieval mission are ~5 km or greater.

<sup>2</sup>Note that Perseverance can add samples to an established depot before embarking on a challenging traverse.

<sup>3</sup>Sample acquisition by Perseverance should be managed by the Mars 2020 science team in accordance with the mission's *in-situ* science and sampling objectives. What constitutes an SRW sample collection should be decided by the NASA and ESA MSR partners based on the input of the M2020 science team.

## Strategic Intent #2 & Decision Guideline

2. STRATEGIC INTENT: To maximize the scientific diversity and significance of samples available for return, Perseverance should plan to form a second SRW sample collection. This second SRW sample collection should include samples from the geological settings represented in the first depot and additional samples acquired after the first depot has been established.

#### Decision Guideline

- Duplicate sampling for selected samples should be implemented to enable the formation of subsequent SRW sample collection(s). Decisions related to which samples to duplicate should be managed by the Mars 2020 science team.

## Strategic Intent #3

3. STRATEGIC INTENT: To safeguard the delivery of an SRW sample collection to the Sample Retrieval Lander (SRL), two sample delivery pathways (one involving the Sample Fetch Rover (SFR)<sup>4</sup>, and one involving Perseverance<sup>5</sup>) should be maintained.

Decision Guidelines related to this strategic intent will be formulated at a later date when more information (e.g., Perseverance landing location and actual performance in the field, the nature and significance of any degradation with time of Perseverance's capabilities, science assessment of the exploration area vs pre-landing interpretation, SFR design and qualification program) is available.

<sup>4</sup>SFR cannot retrieve samples directly from Perseverance, so loss of Perseverance mobility or depot placement capability could result in the absence of an SRW sample collection as target for SRL.

<sup>5</sup>Perseverance does not have the capability to pick up sample tubes placed on the surface, so if SFR fails, any samples previously placed on the surface by Perseverance are not recoverable.

## SRW-General Understanding & Assumptions

1. Scientifically Return Worthy (SRW) is the property of a collection of samples and not the property of an individual sample, except in extraordinary circumstances.
2. Sample suites are a collection of related samples. Individual samples may be part of multiple suites and may address multiple science objectives.
3. An SRW sample collection is the minimal collection of samples that could significantly advance our understanding related to major science objectives of MSR described by iMOST<sup>1</sup>, including the history and evolution of the Jezero Crater region.
4. The definition of an SRW sample collection applies to any/all sample collections. Note that a sample collection can be on the ground (i.e. a depot) or on a rover.
5. We can reasonably expect that a diverse collection of samples from Jezero Crater would satisfy the requirements for an SRW sample collection.
6. The scientific aim for MSR is to maximize the science return and to go beyond the minimal SRW sample collection. This could include returning a sample collection that includes samples from outside Jezero Crater.

## SRW-Definition

Previous experience has demonstrated that every time samples have been returned from other solar system bodies (Moon, comet, asteroids), they have revolutionized our understanding of that body, Earth's origins, and the history of our solar system. Mars Sample Return offers a novel chance to carefully select samples and document their geologic context, enabling the return of a scientifically compelling sample collection that will significantly advance our understanding of Mars as a planet, its astrobiological potential, and comparative planetology of terrestrial planets.

A Scientifically Return Worthy sample collection should:

1. Include distinct sample suites or individual samples selected to represent the diversity of the exploration area and to address the science objectives of MSR described by iMOST<sup>1</sup>, in general, and the astrobiological potential, geologic history, and evolution of Mars as reflected in the Jezero Crater region, in particular.
2. Be accompanied by *in-situ* data and information sufficient to understand the geological and environmental context of the samples.
3. Include at least one, and preferably two, witness samples.

## Acknowledgements:

A portion of this work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004)

The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for planning and information purposes only.

## References:

1. iMOST (International MSR Objectives and Samples Team: co-chairs: D. W. Beaty, M. M. Grady, H. Y. McSween, E. Sefton-Nash; documentarian: B. L. Carrier; team members: F. Altieri, Y. Amelin, E. Ammannito, M. Anand, L. G. Benning, J. L. Bishop, L. E. Borg, D. Boucher, J. R. Brucato, H. Busemann, K. A. Campbell, A. D. Czaja, V. Debaille, D. J. Des Marais, M. Dixon, B. L. Ehlmann, J. D. Farmer, D. C. Fernandez-Remolar, J. Filiberto, J. Fogarty, D. P. Glavin, Y. S. Goreva, L. J. Hallis, A. D. Harrington, E. M. Hausrath, C. D. K. Herd, B. Horgan, M. Humayun, T. Kleine, J. Kleinhenz, R. Mackelprang, N. Mangold, L. E. Mayhew, J. T. McCoy, F. M. McCubbin, S. M. McLennan, D. E. Moser, F. Moynier, J. F. Mustard, P. B. Niles, G. G. Ori, F. Raulin, P. Rettberg, M. A. Rucker, N. Schmitz, S. P. Schwenzer, M. A. Sephton, R. Shaheen, Z. D. Sharp, D. L. Shuster, S. Siljestrom, C. L. Smith, J. A. Spry, A. Steele, T. D. Swindle, I. L. ten Kate, N. J. Tosca, T. Usui, M. J. Van Kranendonk, M. Wadhwa, B. P. Weiss, S. C. Werner, F. Westall, R. M. Wheeler, J. Zipfel, and M. P. Zorzano) (2019), The Potential Science and Engineering Value of Samples Delivered to Earth by Mars Sample Return, *Meteoritics & Planetary Science*, vol. 54 (3), p. 667-671 (executive summary only), <https://doi.org/10.1111/maps.13232>; full report (*Meteoritics & Planetary Science*, vol. 54, S3-S152): <https://doi.org/10.1111/maps.13242>.

## Appendix I: CSSC ToR and Membership



### **Terms of Reference** **Caching Strategy Steering Committee**

#### **Purpose**

This document establishes the Terms of Reference for the Mars Sample Return (MSR) Caching Strategy Steering Committee.

#### **Introduction**

In October 2020, NASA and ESA formalized a partnership to bring samples of Mars to Earth. One crucial piece of planning that will have a large impact on the potential number, nature, and diversity of returned samples, and thus on the science that can be performed on the samples, is the caching strategy for the samples collected by the rover Perseverance. The retrieval of cached samples requires transport by one of two pathways: 1) retrieval of cached samples by the Sample Fetch Rover (SFR) and then transport to the Sample Return Lander (SRL); or 2) delivery of samples retained on Perseverance to the SRL. There are multiple options to caching. The samples can be cached in one or several depots on the surface of Mars and on the Perseverance rover itself and both pathways utilized. Which strategies are actually implemented will depend on the nature and perceived value of each sample, the diversity of the samples at a depot, landing site accessibility for SRL, the capabilities of Perseverance and Sample Fetch Rover, lifetime projections for Perseverance and SFR, and the projected risk of rover survivability and trafficability of the terrain encountered. Potential scenarios may include acquiring duplicate samples as well as where, when, and how many depots are established.

A Caching Strategy Steering Committee is being chartered to review a set of scenario-based decision guidelines to inform operational decisions for future MSR systems (SRL, SFR) and provide strategic guidance to operations mission planning for Perseverance. The Steering Committee will include representatives of each of the MSR stakeholder organizations: NASA, ESA, Perseverance, MSR, and the Mars science community. An open workshop with the science community will be conducted to share and discuss planned scenarios, with feedback provided to the missions. The results of the workshop will be incorporated into Steering Committee deliberations and documented in a short report. The report of the Steering Committee will be used to inform caching strategy and priorities, as documented in the MOU between the MSR and M2020 teams.

*Pre-decisional, for planning and discussion purposes only*

### **Assumptions:**

1. The Workshop will be conducted virtually in January 2021.
2. The objective is to maximize the scientific value of the sample collection that could be loaded into the sample container on the Mars Ascent Vehicle for sample return to Earth.
3. Perseverance will have the sole ability to collect and encapsulate solid samples (rock and regolith).
4. SFR will be able to retrieve samples on the surface of Mars, not from Perseverance itself.
5. Perseverance and SFR will independently have the ability to transport collected samples to the SRL.
6. SFR may not be able to access all of the pathway traversed by Perseverance.
7. Due to terrain accessibility and surface timeline constraints, SFR is unlikely to access more than one depot and return these samples to SRL.
8. The M2020 Science Team will be responsible for determining which and how many samples are acquired in the exploration area.
9. The MSR Program will run a landing site selection process to determine the landing location of SRL; final landing site decision authority will be held by the NASA-ESA partnership,
10. The MSR and M2020 teams have a draft MOU in place that outlines planned scenarios for M2020 and MSR/SRL surface operations related to sample depot placement and site characterization. This draft MOU will be briefed to workshop participants.

### **Statement of Task**

1. Review a set of options for scenario-based decision guidelines that can be used to inform the Perseverance caching strategy, within the constraints of Perseverance sample handling, SRL landing site selection, and SFR operations planning.
2. Organize and implement a virtual workshop in January 2021, that will be open to the science community to discuss and provide feedback on these options.
3. Provide a report documenting the results of the workshop and recommend caching strategy guidelines for the M2020 and MSR teams.
4. Deadline for the final report is within one month of the Workshop conclusion.

### **Logistics**

- Co-chairs will consist of NASA and ESA MSR science representatives.
- The logistics for the team will be managed by the MSR Program Office at JPL, and will be supported as needed by NASA and ESA.
- For reasons of cost, time, and the COVID-19 pandemic, it is expected that most of the work will be carried out virtually (e-mail, teleconferences, etc.).



ERIC  
IANSON

Digitally signed by ERIC  
IANSON  
Date: 2020.10.28  
08:42:36 -04'00'

---

Eric E. Ianson  
Mars Exploration  
Program, Director  
NASA Headquarters

Jeffrey  
Gramling

Digitally signed by Jeffrey  
Gramling  
Date: 2020.10.29  
08:17:24 -04'00'

---

Jeff Gramling  
Mars Sample Return  
Program Director  
NASA Headquarters



Francois Spoto  
2020.11.09  
14:20:38 +01'00'

---

Francois Spoto  
Mars Exploration Group Leader (acting)  
Directorate of Human & Robotic Exploration (D/HRE)  
European Space Agency

## Appendix II: CSSC Membership

<u>Name</u>	<u>MSR Role</u>	<u>Affiliation</u>
Michael Meyer	NASA MSR Science Lead	NASA HQ
Gerhard Kminek	ESA MSR Science Lead	ESA-ESTEC
Lindsay Hays	NASA MSR Deputy Science Lead	NASA HQ
Ken Farley	Mars 2020 Project Scientist	Caltech
Mitch Schulte	Mars 2020 Program Scientist	NASA HQ
Jennifer Trosper	Mars 2020 Deputy Project Manager	Jet Propulsion Laboratory/California Institute of Technology
Chris Herd	Mars 2020 RSS Rep (co-chair)	University of Alberta
Tanja Bosak	Mars 2020 RSS Rep (co-chair)	Massachusetts Institute of Technology
Frederic Moynier	Mars 2020 RSS Rep	Institut de Physique du Globe de Paris
David Spencer	MSR Program Rep (JPL)	Jet Propulsion Laboratory/California Institute of Technology
Albert Haldemann	MSR Program Rep (ESA)	ESA-ESTEC
Juan Delfa	SFR Operations Rep (ESA)	ESA-ESTEC
David Beaty	MSR Campaign Science	Jet Propulsion Laboratory/California Institute of Technology
Brandi Carrier	MSR Campaign Science	Jet Propulsion Laboratory/California Institute of Technology
Jorge Vago	ESA Science	ESA-ESTEC
Audrey Bouvier	Science-External	University of Bayreuth
Monica Grady	Science-External	Open University
John Grant	Science-External	Smithsonian Institute
Sanjeev Gupta	Science-External	Imperial College London
Laurence Lemelle	Science-External	CNRS-Lyon
Kirsten Siebach	Science-External	Rice University
Lindy Elkins-Tanton	Science-External	Arizona State University
Meenakshi Wadhwa	Science-External	Arizona State University
Karen Ziegler	Science-External	University of New Mexico

## Appendix III: MSR Caching Strategy Workshop

### Workshop Agenda

Introduction/Context/Goals of the Workshop	Kminek /Meyer	8:00 AM
Questions		8:10 AM
Perserverance operational scenarios & constraints of relevance to caching & retrieval	Farley	8:20 AM
Questions		8:30 AM
Geology & Potential Sampling Opportunities (Includes notional mission traverse & timeline)	Gupta	8:40 AM
Questions		9:05 AM
Caching Strategy Considerations	Spencer/Delfa/Do	9:15 AM
Questions		9:45 AM
Break		10:00 AM
Draft Decision Guidelines	Meyer	10:10 AM
Discussion: Feedback on Draft Decision Guidelines		10:20 AM
Scientifically-Return Worthy	Kminek	10:40 AM
Discussion: Scientifically-Return Worthy criteria		10:50 AM
Implications of Draft Decision Guidelines (e.g. duplicate sampling, number of caches, key decision points).	Haldemann	11:10 AM
Discussion		11:20 AM
Concluding the workshop, next steps	Meyer/Kminek	11:40 AM

All workshop presentation material can be viewed at

<https://mepag.jpl.nasa.gov/announcements.cfm?expand=January%202021%20MSR%20Sample%20Caching%20Workshop>

**Mars Exploration Program/Mars 2020 project  
Concept of Operation Guidelines Agreement**

**with the**

**Mars Sample Return Program**

Version: Initial Version 1.0  
Release: December 8, 2020  
Custodian: David A. Spencer

MEP/M2020 ConOps Guidelines Agreement with MSR

*This document has been reviewed and determined not to contain export controlled data.*

## Approving Signatures

Prepared By: <b>E-SIGNED by David Spencer</b> Date: on 2020-12-11 00:45:04 GMT	David Spencer Mission System Manager Mars Sample Return Program
Approved: <b>Matthew Wallace</b> Date: Digitally signed by Matthew Wallace Date: 2020.12.14 12:53:01 -08'00'	Jennifer Trosper Deputy Manager, Mars 2020 Project Mars Exploration Program
Approved: <b>E-SIGNED by John McNamee</b> Date: on 2020-12-13 18:59:20 GMT	John McNamee Manager, Mars 2020 Project Mars Exploration Program
Approved: <b>E-SIGNED by Chris Salvo</b> Date: on 2020-12-14 16:57:48 GMT	Chris Salvo Manager, Campaign System Engineering and Integration Office Mars Sample Return Program
Approved: Date:	Albert Haldemann Mars Exploration Group Chief Engineer European Space Agency

## Concurring Signatures

Acknowledged: <b>E-SIGNED by Matthew Wallace</b> Date: on 2020-12-12 22:16:27 GMT	Matthew Wallace Deputy Project Manager, Mars 2020 Project Mars Exploration Program
Acknowledged: <b>E-SIGNED by Kenneth Farley</b> Date: on 2020-12-11 02:45:42 GMT	Kenneth Farley Project Scientist, Mars 2020 Project Mars Exploration Program
Acknowledged: <b>E-SIGNED by Fuk Li</b> Date: on 2020-12-11 00:43:42 GMT	Fuk K. Li Manager, Mars Exploration Program
Acknowledged: <b>E-SIGNED by Robert Braun</b> Date: on 2020-12-11 01:44:43 GMT	Robert Braun Manager, Mars Sample Return Program

## Document Change Log

Release	Date	Affected Portions
1.0	December 8, 2020	Original document LRR053431

## Unresolved Items in This Version

Location	Description

## **Table of Contents**

<b>1. Introduction: Purpose and Scope .....</b>	<b>5</b>
<b>2. Guidelines for Depot Placement for Mars 2020.....</b>	<b>5</b>
<b>3. Guidelines for SRL Landing Site Characterization.....</b>	<b>6</b>
<b>By Mars 2020</b>	
<b>4. Schedule Milestones .....</b>	<b>7</b>

# 1. Introduction: Purpose and Scope

This document outlines planned scenarios for Mars 2020 project (M2020) and Mars Sample Return (MSR)/Sample Retrieval Lander (SRL) surface operations related to sample depot placement and site characterization as agreed by M2020 and MSR. The following guidelines are based on current understanding and assumptions of M2020 and MSR/SRL mission capabilities and plans. It is planned that the Mars 2020 project will prepare quarterly updates on the mission health and sample collection status during its operation. This document will be reviewed and updated in response to a caching strategy workshop to be held in 2021 and annually as improved knowledge of capabilities and operational considerations are known. This document is not intended to constitute a modification to Mars 2020 Level 1 requirements, mission success criteria, or the level of risk accepted by the Agency for the prime mission.<sup>1</sup>

## 2. Guidelines for Depot Placement by Mars 2020

1. Prior to beginning the climb to the crater rim, the Mars 2020 team will create an initial depot at a green zone<sup>2</sup> within Jezero if a scientifically return-worthy (SRW) sample collection has been acquired.<sup>3</sup>

Rationale: The traverse from Jezero crater to the crater rim is through difficult terrain, and the traverse path lengths between green zones are ~5 km or greater (see Figure 1). As a risk reduction measure, an initial depot should be placed before attempting the climb out of Jezero crater. If the set of samples acquired prior to exiting Jezero is not SRW, the samples should be retained for future depot placement, or for direct delivery to SRL.

2. At the discretion of the Mars 2020 team, duplicate sampling will be implemented for select high-value samples to enable the establishment of the initial depot, while retaining duplicate samples for later depot placement or retention on-board Perseverance for direct delivery to SRL.

Rationale: Acquiring duplicates of select samples preserves maximum science value of both the initial depot and any subsequent depot or direct delivery to SRL.

---

<sup>1</sup> Changes to information and requirements contained in the Mars 2020 Program-Level Requirements Appendix (PLRA) or to the level of risk in achieving mission objectives within the prime mission require approval by the Science Missions Directorate.

<sup>2</sup> In this context, a green zone is one of many MSR-defined potential depot locations that is connected via a green path to a potential SRL landing zone. Green zones are shown in Figure 1.

<sup>3</sup> Sample acquisition by Perseverance will be determined by the Mars 2020 team in accordance with the mission's in-situ science and sampling objectives. What constitutes a SRW sample collection will be decided by the NASA and ESA MSR partners after acquisition.



3. While Perseverance remains healthy, a set of samples with high science value will be retained on-board.

Rationale: This approach allows the potential for direct delivery of high science value samples from Perseverance to SRL, and mitigates the risk of potential SFR failure. Perseverance does not have the capability to pick up sample tubes placed on the surface, so if SFR fails, any samples previously placed on the surface by Perseverance are not recoverable.

4. If Perseverance contains a SRW sample collection and experiences significant degradation that could result in compromised mobility or sample placement capability, Perseverance will be moved to a green zone and will create a depot. The urgency of this effort will be commensurate with the perceived risk, including details of Perseverance health, the science value of samples on board Perseverance, and whether a SRW cache has already been deposited.

Rationale: Loss of mobility or depot placement capability could result in the absence of a SRW cache as target for SRL.

5. Perseverance will be within [10] sols of the SRL landing site at the time of SRL landing if direct delivery of samples to SRL is planned.

Rationale: The SRL surface timeline is limited based upon solar energy, and the Mars Ascent System must be launched by  $L_s = 180$ . Having Perseverance within a short traverse of the landing site at the time of landing increases the likelihood that the on-board samples will be delivered to SRL within the allowable timeline.

6. For each depot placed, the Mars 2020 team will provide documentation imagery including stereo pairs covering the entire depot area, with image resolutions suitable for traverse planning.

Rationale: The documentation imagery of the depot area will be used by MSR to plan tube pickup and traverse activities.

7. For each Returnable Sample Tube Assembly (RSTA) placed on the surface, the Mars 2020 team will provide stereo imagery documentation of: (1) the site prior to the drop; (2) the RSTA on the surface after the drop; and (3) the RSTA from a second perspective after the drop.

Rationale: The documentation imagery of the RSTAs and the terrain in the drop area will allow a priori planning of RSTA grappling by SFR.

### **3. Guidelines for SRL Landing Site Characterization by Mars 2020**

1. Prior to depositing a depot, the Mars 2020 team will provide imaging data of the landing site green zone to MSR, for certification of SRL landing site safety.

Rationale: Landing site characterization is required prior to depot placement. SRL is susceptible to landing hazards including rocks, slopes, and unstable surface material. The reliability of SRL landing will be greatly enhanced by ground-truth imaging data from Mars 2020.

### **4. Schedule Milestones**

1. The MSR Campaign will determine the SRL landing site no later than 9 months prior to SRL arrival at Mars. Any depots created by Perseverance will have been placed prior to this date.

Rationale: The determination of the SRL landing site [9 months] prior to Mars arrival allows adequate time for EDL planning and preparation. The landing site will be selected based upon the placement and composition of depots, including any samples that are retained on-board Perseverance. Additional samples may be delivered to the SRL-targeted depot after this point in time.

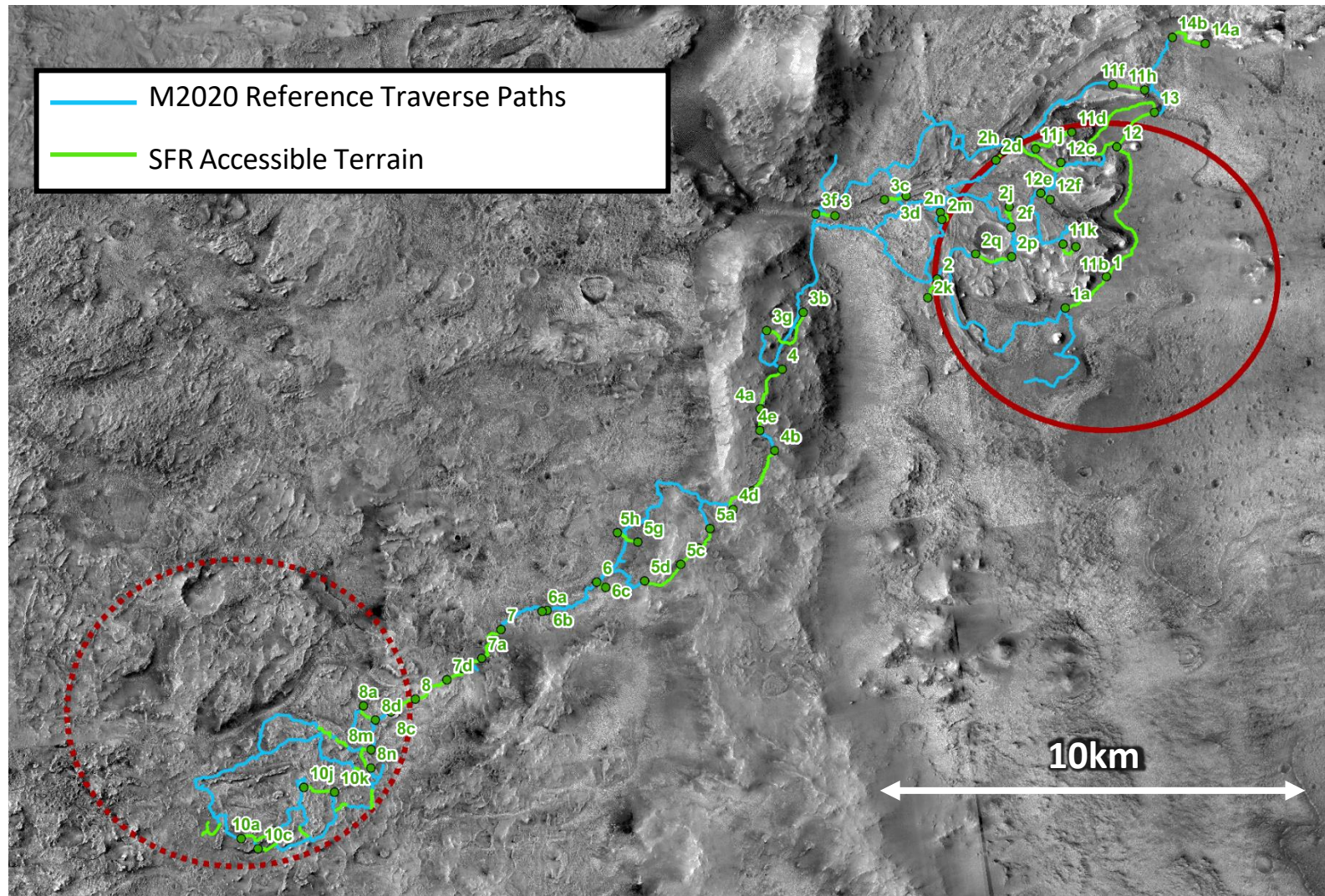


Figure 1. Mars 2020 reference traverse paths and green pathways showing accessible terrain for the Sample Fetch Rover.